AGRICULTURAL ECONOMICS RESEARCH

April 1975 ● Vol. 27, No. 2

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U.S. DEPARTMENT OF AGRICULTURE Economic Research Service

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Because of delays in preparation, this issue of *Agricultural Economics Research* was not printed until July 1975.

AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the United States Department of Agriculture and Cooperating Agencies

April 1975 ● Vol. 27, No. 2

Effects of Trade Liberalization on U.S. Agriculture

By James Vermeer, David W. Culver, J. B. Penn, and Jerry A. Sharples

A shift to worldwide free trade would improve prospects for U.S. livestock and grain producers. Both production and prices would be higher for meat animals and poultry, but but milk prices would be lower. Producers of peanuts, sugar, and some fruits and vegetables would face lower price and income prospects. For agriculture as a whole, expanded production and relatively strong prices would generate about 5 percent more in cash receipts. Production expenses would be higher. Without Government payments, realized net farm income would be a little lower than under continuation of present programs. But slight differences in prices could shift the balance either way.

Keywords: Free trade, projections, trade liberalization.

Instead of mounting surpluses, increasing storage costs, and Treasury expenditures for farm commodity programs, rising consumer food costs have become a principal concern of people interested in U.S. agricultural policy. Associated with this changed emphasis is a renewed interest in foreign trade policy for agricultural commodities and the effects of liberalized trade on the U.S. food and fiber sector of the economy.

The current round of international trade negotiations (GATT) has renewed interest in the implications of the removal of both tariff and nontariff trade barriers on the domestic food and fiber sector. The recently twice devalued dollar and the current floating dollar have fostered more favorable trading conditions for U.S. products. Newly established detente with the People's Republic of China and the possibility of expanding the rudimentary trade begun in 1973, along with increased Russian trade, have received widespread attention. More recently, the energy situation has prompted concern for the balance of payments and the role of agricultural exports in U.S. trade. Expanding foreign demand for U.S. agricultural products has in part allowed the currently relaxed production controls and reduced Treasury costs for associated farm programs.

This study focuses on the probable impact of free trade on the input, production, and processing sectors of U.S. agriculture. The purpose of this analysis is not to produce point projections but to suggest general magnitudes and tendencies—to sketch possible adjustments resulting from trade liberalization. It is based not on the results of a formal mathematical model, but rather on less formalized analyses. It builds on recent studies of the probable effects of agricultural trade liberalization on the livestock and grain economies of the United States, Western Europe, and Japan. In addition, the analysis considers effects of free trade on peanuts, cotton, tobacco, rice, wool, and fruits and vegetables.

The basic analyses of world trade on which this paper rests were completed in the spring of 1973. Thus, the findings do not reflect possible effects of the energy shortage on U.S. farm production, or on world supply or demand, or trade in farm products. Depending on the magnitude and duration of the energy shortage, the level of supply, demand, and trade might differ substantially from the projections in this report. Supply functions could shift downward because of higher prices or shortages of fertilizer, fuels, and transportation. And demand functions might shift because of the effect of the shortages on economic growth and the balance of payments. The comparative results are very tenuous for commodities such as peanuts and dairy products for which we have had extensive production or trade restrictions for many years.

The analysis examines world and U.S. agricultural trade under two alternatives. The first assumes continuation of current domestic and foreign agricultural policies of the United States and major trading countries. For the United States this means that at times production could be restrained to support prices. For all countries, current tariffs, quotas, variable levies, and other protective measures would be maintained. In effect, however, no country operates for a long period without adjustments in "current" policies. Thus, these projections reflect the range of probable situations in 1985, but they are not predictions of programs that will prevail even if current policies are continued.

The second alternative assumes free trade, under which restraints would be removed early by the major trading countries and the economies would fully adjust to the new situation in about 10 years. However, free trade is unlikely within the period considered in this analysis. Rather, the assumption of free trade indicates conditions at the end of a whole series of actions that could be taken in moving toward free trade, and they

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provide a background against which realistic adjustments could be made. Results of projections under the two alternatives are compared for 1985. In either case, output in 1985 is expected to be substantially larger than in 1973.

Assumptions

For both alternatives—continuation of current policies and free trade—U.S. population is assumed to be 236 million in 1985—an increase of 0.9 percent a year, in line with Series E projections of the Census Bureau. Also, the medium variant of the UN population growth rate averaging 2.1 percent a year was assumed for other countries. Inflation in the United States is assumed at the rate of 3 percent a year, with a slightly higher rate—3.5 to 4 percent—for other countries. Although these rates may appear low in light of recent experience, they are near the averages of the last 20 years. Use of different inflation rates would change the price and farm income levels indicated by 1985, but would have a minimal effect on the comparisons between free trade and current policies.

World income projections generally are extensions of the trends in gross domestic product and private consumption expenditures from 1955 to 1970.

Specific assumptions for continuation of current policies:

1. Provisions of the Agriculture and Consumer Protection Act of 1973 remain in effect for wheat, feed grains, cotton, and milk.
2. Current minimum allotments and price supports for peanuts, rice, and tobacco continue.
3. Current tariffs, quotas, and other import restrictions continue for agricultural commodities on a worldwide basis.
4. Current agricultural policies in major producing countries continue.

Specific assumptions under free trade:

1. No national allotments or marketing quotas are applied in the United States or other major producing countries.
2. No support prices are used; any income support programs would be designed to have a neutral effect on production.
3. No restrictions are placed on agricultural trade between countries.

Although exports of oilseeds to the Communist countries would be expected to increase by 1985, trade in other products would not differ materially from 1970. Furthermore, it was assumed that these countries would not be involved in plans for trade liberalization and therefore their level of trade would not be directly affected. If the USSR and the People's Republic of China should decide to improve the diets of their people at a faster rate, their import demand for food products would raise worldwide prices and production to a higher level than projected in this analysis.

For major crops, expected yields per acre in 1985 compared with those in the base period are as follows:

Crop	*1971-73*	*1985*
Corn	92.0 bu.	120 bu.
Wheat	32.8 bu.	36.6 bu.
Soybeans	27.7 bu.	34.5 bu.
Cotton (lint)	489 lb.	535 lb.

Results for Major Commodities[1]

Meat animal producers in the United States would generally be in a strong competitive position under free trade.

The meat import law of 1967 authorizes, but does not require, the President to impose quotas on imports of beef, veal, and mutton whenever imports are estimated to exceed a trigger amount set by formula. Beef and veal imports are subject to a duty of 3 cents per pound, lamb 1.7 cents per pound, and pork 0.5 cent. Meat imports are also subject to substantial duties in the European Community (EC) and Japan. In 1973, the United States imported 2,052 million pounds of beef and veal (carcass weight equivalent), 73 million pounds of lamb and mutton, and 491 million pounds of pork. Combined, these amounted to about 7 percent of total U.S. red meat supplies. Exports of red meats totaled 464 million pounds, with pork accounting for about two-thirds of the total.

Presently, import duties and restrictions are higher in Europe and Japan than in the United States. With the removal of all trade restrictions, effective world demand for meat would rise, and U.S. production, exports, and prices would be higher than under current trade policies. The United States would have a competitive advantage in the production of fed beef. U.S. production and exports of fed beef would rise and U.S. fed cattle prices could be about 10 percent higher as a result of larger exports to Japan and Western Europe, but imports of lean beef from Australia, New Zealand, and Latin America also would rise. With higher feed prices under free trade, U.S. pork production would be nearly the same as with current policies. With larger exports, chiefly to Japan, prices in the United States would be higher. Lamb and mutton production in the United States would decline even more rapidly under free trade than with a continuation of current policies since other countries, particularly Australia and New Zealand, would maintain a competitive advantage in production.

Under existing trade policies, poultry producers in the United States would probably remain residual or marginal suppliers of poultry products to world markets, while further growth occurs in foreign countries. Under free trade the United States would be in a more favorable competitive position initially with production

[1] Initial drafts of commodity statements were prepared by commodity specialists in the Commodity Economics Division, ERS.

and prices higher than under current policies. U.S. exports to the more highly protected markets such as the EC would increase substantially immediately following removal of the barriers. But the net impact of free trade on the U.S. poultry industry would be modest because adjustments could be made fairly quickly in other countries.

Milk production in this country could be nearly 10 percent lower under free trade in comparison with continuation of current policies.

At present, the United States has an extensive system of quotas and duties which limit dairy product imports. Also, many other countries, particularly in the EC, have domestic price guarantees, restraints on trade, and programs to encourage exports of dairy products.

With current policies, U.S. milk production probably would remain about stable or increase a little in comparison with recent levels. But, under free trade, production and prices would probably run lower, because of strong competition from Oceania and possibly Western Europe. The number of dairy farms would decline sharply in either situation, but the adjustment would be more severe under free trade.[2]

Grain prospects would be substantially improved by free trade. Increases in both production and prices would follow sharp gains in export demand.

Import barriers to grain trade take a variety of forms—tariffs, levies, quotas, embargoes, and standards and grades. Quantitative regulations are substantial on trade in wheat, corn, barley, and grain sorghums. An example is the variable levy on corn imports into the EC, which was equivalent to a 57 percent tariff in 1969-70.

U.S. wheat producers enjoy substantial competitive advantages over producers in most other areas of the world. Consequently, without acreage restrictions wheat production might be nearly 6 million metric tons larger under free trade. About a fifth of this greater production would be consumed as feed in the United States, since higher feed grain prices would make wheat more competitive. Most of the remainder would be exported to the EC countries. Wheat prices would probably be about the same under the two alternatives.

Under free trade, other countries as well as the United States would remove import restrictions and price supports on rice. Thus, in Japan, for example, prices and production would be expected to be lower. With lower prices and production in Japan and in other countries with similar policies, imports by those countries would be higher under free trade, resulting in higher world prices for rice. With world prices under free trade about 15 percent higher than with current policies, production in the United States would expand nearly a third.

Although some other exporting countries are relatively low-cost producers, the United States is the only country that currently has a program to restrict rice production. It is thus the only country in which production could expand if all restrictions on production and trade were removed.

Feed grain prices would be a little higher under free trade, and the strong U.S. competitive advantage in feed grains and the absence of production restrictions would be expected to result in sharply higher production. Feed consumption in the United States would be about the same under either alternative. Most of the additonal production would be exported to the EC and Japan.

Free trade conditions would bring mixed results in oilseeds, with soybeans benefiting moderately but peanut prices 60 percent lower.

Soybeans are now traded in world markets largely without restrictions. The impact of free trade on the U.S. soybean industry would be through greater demand for feed and higher price levels for grains—the major competitive crops for soybeans. Soybean production would be about the same while prices would be moderately higher under free trade. With expanded demand for feed grains under free trade, corn acreage would increase in the Corn Belt. This would accelerate the increase in soybean production outside the Corn Belt, particularly in the Southeast.

With free trade in peanuts, production would be about a fourth higher. But with sharply lower prices, the value of production in 1985 would be less than half of what it would be if current policies are continued. Despite lower prices and higher production costs in 1985, however, under free trade peanuts still would be more profitable than other crops in most areas where peanuts are adaptable. Also, peanut acreage would expand from the restricted levels allowable under current policies.

With a shift to free trade, U.S. cotton production and prices probably would be lower, both by around a tenth, and textile imports would be larger.

Imports of raw cotton into the United States are limited by strict quotas under current policy. Cotton textile imports also are under quotas and tariffs. The United States now has long-term bilateral agreements with Japan and 27 other countries covering over four-fifths of cotton textile imports.

Some marginal producers in the United States probably would not be competitive under free trade conditions. However, the major cause of decline in cotton production would be the increased profits available from other enterprises. With higher prices for feed grains, soybeans, and beef cattle under free trade, many cotton farmers would shift to the more profitable enterprises and cotton production would decline. More of the cotton production would be concentrated in the Delta with reductions likely in the Southeast and Southwest.

Wool production and prices under free trade would both be expected to drop sharply. The present tariff on imports of apparel wool into the United States is around 25 cents a pound, with variation according to grade.

[2] A more detailed study of the impact of increased dairy imports on the U.S. dairy industry is available in Agricultural Economic Report No. 278, ERS, USDA, Jan. 1975.

Producers are guaranteed a specified target price. Under free trade, domestic wool production might drop by two-fifths in comparison with output under current policy. And farm prices would be expected to run a fifth lower.

The U.S. tobacco industry is protected by comparatively low duties on imports, as well as price supports and quotas on about 95 percent of production. Embargoes are placed on tobacco originating in Cuba, North Korea, North Vietnam, and Rhodesia, while Philippine tobacco is given preferential treatment. The United States has recently subsidized tobacco exports at the rate of 5 cents a pound. Foreign nations use a variety of price guarantees, export subsidies, and import levies to restrict trade in tobacco.

With free trade, U.S. tobacco prices would be a little lower than under current policies but production might be a fifth higher because of stronger export demands.

Free trade would result in mixed prospects for fruits and vegetables. Citrus production and prices would be stronger, but producers of other fruits and vegetables would face strong competition in some markets.

Trade barriers for fruits and vegetables vary widely, but duties are generally low. Imports into the United States face modest tariffs on a number of items in addition to requirements relative to pests, diseases, and quality standards.

The EC countries use variable levies on fruit and vegetable imports. However, several non-EC Mediterranean countries receive preferential rates. The EC also maintains domestic support prices for a number of fruits and vegetables. Japan attempts to stabilize domestic fruit and vegetable supplies by minimum price guarantees and quality requirements on some products.

Under free trade U.S. citrus production, exports, and prices would be substantially higher because of greater exports, chiefly to Japan. However, U.S. producers of vegetables for fresh markets would be at a substantial competitive disadvantage in the U.S. market compared with producers in Mexico and several other Latin American countries. The impact of free trade would be relatively small on noncitrus fruit.

The United States would remain competitive in those fruits and vegetables for which production can be mechanized and for which large amounts of capital are required in processing or transporting. Under free trade, the United States would be likely to face strong competition from developing countries that produce labor intensive fruits and vegetables.

Under free trade, U.S. fresh tomato production could fall as much as 75 percent and prices could decline perhaps a fifth relative to continuation of current policy. Florida, Texas, and California producers would be most severely affected, both by lower prices and by less production. Also, significantly larger shipments of cucumbers, peppers, fresh strawberries, and melons would be received from Mexico. For processing tomatoes, U.S. production would decline at least a tenth, with the most severe adjustments in Eastern and Midwestern producing regions. Imports of canned mushrooms, canned asparagus, and frozen strawberries would also increase.

The effect of free trade on the world sugar economy would result in a market price somewhat below the protected U.S. domestic price, but above the level of world market prices in all except a few years since World War II.

Nearly half of U.S. sugar consumption is from imports. Production in this country at times is restricted and imports into the United States are under an allocation program. The U.S. sugar program (scheduled to end when the 1974 crop has been marketed) makes subsidy payments to domestic producers, imposes an excise tax of 0.5 cent a pound (raw value) on all sugar marketed, and provides for a tariff of 0.625 cent a pound on imported sugar. In addition, a tariff of 2.5 cents a pound on refined sugar and a quota of about 70,000 tons a year effectively limit refined sugar imports.

A movement to free trade in sugar would be expected to force out a substantial part of the higher cost sugarbeet production in the United States and some sugarcane in Louisiana. But this would take several years, particularly in the cane areas. Also, free trade probably would cause substantial shifts in production to more efficient producing areas such as Brazil, South Africa, and Australia.

Aggregate Effects of Free Trade

Total U.S. farm output would be nearly 5 percent higher under free trade than with continuation of current policies (table 1). This is because U.S. agriculture generally has a competitive advantage in relation to agricultural production in most other countries.

Crop output would be 6 to 7 percent higher under free trade than with continuation of present policies. Important increases would occur in grains, particularly feed grains and rice, and in peanuts and tobacco (table 2). Soybeans would change little. There would be some decline in cotton production and in several vegetables.

Livestock output would be about the same under the two alternatives. With free trade, beef and poultry production would rise and pork output would be about the same, but output of milk and sheep and lambs would decline substantially.

Overall farm prices might average slightly lower with free trade. Livestock prices might be 1 to 2 percent higher while crop prices could be down about 7 percent. Higher prices might prevail for meat animals, particularly beef, and for poultry, grains, soybeans, and citrus fruit. Prices of milk, peanuts, sugar, and fresh vegetables might be lower with free trade.

Changes in net farm income are highly dependent on relatively small changes in total cash receipts, total production expenditures, or Government payments. Thus, whether net incomes would be higher or lower under free trade depends on the effects free trade would

have on these factors. Furthermore, under continuation of current policies, cash receipts and Government payments are related inversely; as prices of some farm products rise, Government payments are reduced.

Table 1. Indexes of U.S. agricultural production, prices, and trade, selected years and projections for 1985 under two alternatives

Indexes	1969-71 average	1972	1973	1985: Continuation of present policy	1985: Free trade
Farm production (1967=100):					
Livestock and livestock products	104	108	107	130	129
Crops	105	113	119	141	150
Farm output	105	111	115	139	145
Prices received by farmers (1967=100):					
Livestock and products	117	134	178	171	173
Crops	105	115	164	148	137
All farm products	112	126	172	162	159
	1970 base	1972/73		1985: Continuation of present policy	1985: Free trade
Volume of trade (1970=100)					
Total exports	100	136		143	190
Total imports	100	107		130	162

Table 2. U.S. production of selected commodities in 1971-73 and projections to 1985 under two alternatives

Commodity (domestic units)	1971-73 average	1985: Continuation of present policy	1985: Percent change from 1971-73	1985: Free trade	1985: Percent change from continuation of present policy
Crops:					
Wheat (mil. bu.)	1,625	1,800	+11	2,000	+11
Feed grains (mil.s.t.)	200	260	+30	300	+15
Soybeans (mil. bu.)	1,338	2,150	+61	2,200	+2
Cotton (thous. bales)	12,400	13,500	+9	12,000	−11
Livestock:					
Beef and veal, carcass weight (mil. lb.)	21,898	31,560	+44	31,990	+1
Pork, carcass weight (mil. lb.)	13,608	16,380	+20	16,380	0
Poultry (mil. lb.)	10,684	14,860	+39	15,090	+2
Lamb and mutton, carcass weight (mil. lb.)	530	318	−40	175	−45
Milk, milk equivalent, fat solids basis (mil. lb.)	118,019	120,400	+2	110,900	−8

Under the assumptions of this study, the expansion of production and little change in prices would generate about 5 percent more cash receipts under free trade. The greater volume of production under free trade would result in larger production expenditures but they would probably be less than the difference in cash receipts from marketings. If present programs were continued, farmers would receive Government payments in 1985, given the assumptions and price relations used in this study. The level of such payments would depend on the relationship of market prices, target prices, and payment provisions prevailing in 1985. Assuming an increase in target prices to reflect a 3 percent annual increase in prices paid by farmers (adjusted for projected yield changes), and market prices projected in this study, Government payments to farmers might approximate $3 to $4 billion in 1985.

Under free trade, we have assumed no mandatory income payments to farmers, and total realized net farm income in 1985 might be somewhat less than under continuation of present programs.

Thus, any negative effect that free trade would have on farmers' net incomes would depend heavily on Government payments. However, if market prices under either set of assumptions were above target prices, Government payments would be small with continuation of current policies, and the larger volume of sales under free trade could provide the higher net income. Alternatively, if Government programs under free trade were designed to support farm incomes while having a neutral effect on production, Government payments could be as large under free trade as they would be if current policies were continued and prices dropped below the target levels. Under these conditions free trade plus Government payments could provide the larger net income.

Under free trade, producers of feed grains, soybeans, rice, and beef probably would benefit. Producers of some products not eligible for direct Government payments would have lower net returns from marketings. These include producers of milk, peanuts, tobacco, some vegetables, and sugar. With the loss of Government payments and lower prices, cotton producers would have lower net incomes. Although wheat production would increase under free trade, greater production expenses and the loss of Government payments probably would result in lower net incomes for wheat producers.

Land Use and Value

If present trade policies are continued to 1985, cropland planted to the seven major crops[2] would be about the same as in 1973, but well above most other recent years. Production increases would result chiefly from increased yields. Compared with 1973, feed grain and wheat acreages would be down 6 percent, soybeans would be up about a tenth, and cotton would change relatively little. Given these acreages and present farm programs, as much as 25 million acres of cropland might be set aside in 1985.

Under free trade in 1985, U.S. farmers might utilize an additional 22 million acres for the seven major crops, compared with land use under continued trade restrictions. More feed grains—primarily corn and sorghum—as well as wheat and soybeans would be planted, but cotton acreage would decline. The additional 22 million acres under free trade would come from land set aside in 1973, from other crops, and from marginal land brought into production because of higher grain and soybean prices. It appears that planted acreage would not be constrained by cropland capacity with either alternative.

Product price differences would lead to some differences in land prices. The higher free trade price for corn and soybeans could raise the value of land suitable for these crops. Land values in the areas suitable for sorghum also would tend to be higher. In the principal wheat and cotton areas, land values would increase little while the value of pasture and rangeland could rise.

Structural Impacts

Free trade would cause shifts in location of production for some commodities. The major impacts would be for dairy, sheep, sugar, peanuts, and vegetables. In addition, some shifts could be expected for tobacco, feed and food grains, soybeans, and meat animals.

Dairy farming faces large adjustments by 1985 under either continuation of present policies or free trade. The number of dairy herds is expected to decline from 649,000 in 1969 to less than a third of that number in 1985 with present policies, and somewhat further with free trade. The number of small herds will decline in all producing regions but the rate of decline will be more pronounced in the North Central and Plains regions.

Producers of milk for manufactured products would be more seriously affected by free trade than fluid milk producers. These producers are concentrated largely in eight North Central States, with the greatest density in the Lake States where alternatives are limited. Some of these producers could shift to alternative enterprises such as grains or beef. Also, to the extent that movement of fluid milk between regions is increased, the differential impact among regions would tend to be reduced.

Under the free trade, beef raising would be concentrated more in the Southeast and Western regions. Pork production would remain in the traditional areas close to feed sources. Production of wool and of mutton and lamb is expected to decline substantially by 1985, and free trade in 1985 would push this further. The greatest impact would fall on producers in the Western range States. Some of the resources used for sheep production would shift to alternative uses, primarily cattle.

[2] Corn, sorghum, barley, oats, wheat, soybeans, and cotton.

Increased production of corn, wheat, and sorghum would come from traditional production areas. Soybean expansion would be in the Southeast and Mississippi Delta. Cotton acreage would be reduced in the Southeast and Southwest as farmers shift to soybeans and feed for livestock, respectively. Tobacco and peanut acreage would be larger in the Southeast. The increase in rice acreage would be mainly in the Mississippi Delta. Production shifts among fruits and vegetables under free trade would involve only very small acreages.

Between now and 1985 the number of farms will continue to decline with a corresponding increase in the average size, but at a slower rate than in the 1960's. Relative to other factors affecting farm size and numbers, trade liberalization would not have a significant influence. Under either trade assumption, the number of farms would decline perhaps to near 2 million by 1985.

Demand for Purchased Inputs

Increased production projected for 1985 will require increased amounts of purchased inputs. Free trade policies would further increase demand for purchased inputs and farm machinery for crop production. The increased acreage would raise total farm power and machinery needs, and the cultivation of more land would require increased fertilizer and chemical inputs to obtain high yields.

Impact on Domestic Consumers

Retail food prices to U.S. consumers would not change appreciably under free trade. Meat prices might be a little higher, but prices of dairy products, some fruits and vegetables, peanuts, and peanut products would be a little lower.[3]

Consumers also would receive some benefits from price declines in nonfood farm products. Lower cotton and wool prices could cause slightly lower clothing prices under the free trade policy. Substantial declines in tobacco prices at the farm level would be expected from a move to free trade, but this would have very little impact on retail price and consumption.

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[3] Detailed analyses may be appropriate for affected food commodities. One recent example is *The Impact of Dairy Imports on the U.S. Dairy Industry*, Agr. Econ. Rpt. 278, Econ. Res. Serv., U.S. Dept. Agr., which forecasts the probable impact of free trade and other trade alternatives on U.S. milk production and prices and retail dairy product prices.

Impact of the Set-Aside Program on the U.S. Wheat Acreages

By Gail D. Garst and Thomas A. Miller

Five factors are found to have had a significant effect on U.S. acreage of wheat planted during 1961-74: (1) acreage allotment, (2) additional diversion for payment through 1970, (3) set-aside acres in 1971-73, (4) relaxation of allotment restrictions, and (5) the market price of wheat for the preceding season. Together, these factors explain over 98 percent of the wheat acreage variation during 1961-74. The wheat set-aside program reduced wheat planting by 0.28 acre for each acre set aside in the winter wheat regions and by 0.62 acre for each acre set aside in the spring wheat region. It reduced the U.S. acreage of wheat planted by 0.41 acre for each acre set aside nationally.

Keywords: Agricultural policies, wheat, set-aside, production response, supply function, T-regression analysis.

Wheat producers in the United States have been affected by various Government commodity programs for a number of years. Although specific requirements and options of the programs have varied, in general they have relied upon restricting the land input as the means of controlling overproduction. Since 1961 two major types of programs, the acreage allotment-diversion and the set-aside programs, have been in effect. Eligibility for benefits under these two programs has required significant adjustments in producers' decisions to plant wheat.

Since participation in the more recent wheat programs has been voluntary rather than mandatory, national agricultural planners and policymakers have faced the increasingly difficult task of predicting producer response under a wide range of program options and market conditions (*1, 5, 6, 9*). For example, over the past 14 years the market price of wheat has varied from below the loan level to more than triple the loan level. July 1 wheat stocks have ranged from a high of over 1.4 billion to a low of under 200 million bushels. During this period, wheat programs have changed from nearly mandatory acreage allotment programs to voluntary general cropland diversion programs based on the set-aside concept. The voluntary nature of participation in the set-aside program, as well as its provisions allowing producers to plant any crops after meeting the set-aside requirements, has led to increased difficulty in predicting wheat acreage responses to adjustments in program provisions.

Nevertheless, the current U.S. and world wheat situation makes it imperative that policymakers have accurate estimates of future wheat acreage as affected by changing market prices and alternative program specifications. Should wheat set-aside be required? If so, what response is expected under alternative set-aside acreages? How will producers respond to the current market prices? The answers to these and many similar questions are essential ingredients for accurate policy decisionmaking.

Objectives of the Analysis

Since passage of the Agricultural Act of 1970, 3 years of experience have been recorded regarding production response to alternative set-aside program provisions. While a data base covering a much longer period of years would be most helpful, statistical estimates of program response can be made using available data. The two objectives of this analysis are (1) to develop a predictive model using historical data and program characteristics that will identify the major policy variables affecting the acreage of wheat planted since 1961, and (2) to obtain a statistically accurate estimate of the impact of changes in set-aside acreage on the acreage of wheat planted. As will be shown in the results section, models developed to accomplish the first objective may not be the most efficient for meeting the second; hence it is useful to consider the objectives separately, though they are closely related.

Programs and Factors Affecting Wheat Plantings

Two major acts of Congress affecting wheat are under consideration in this study. The first is the wheat allotment-diversion program encompassed in the Food and Agriculture Act of 1965 and in effect from 1966 through 1970. The second is the set-aside program established by the Food and Agriculture Act of 1970 for the 1971-73 crop years and substantially extended in 1973 for the 1974-77 crop years. The "emergency" or 1-year programs enacted for the 1962-65 crops may be viewed as modifications of the 1965 act for purposes of this analysis.[1]

[1] A summary of these programs has been compiled by Hadwiger (*4*).

Under the diversion programs, participating wheat producers were given acreage allotments which served as upper limits on their plantings. For specific years, participation in the programs offered the additional option of diverting acres below that allotment for additional payments. In certain instances overplanting of allotments was also allowed. Producers participating in these programs were required to withhold land from wheat by diverting to fallow or conserving uses. Compliance with program requirements insured producer eligibility for program benefits which included use of the loan support option and receipt of diversion payments for specific years.

Under the set-aside program, participating producers were required to withdraw cropland from production. However, any crop or crops could be planted as long as the normal conserving base and set-aside acreage were maintained. Benefits accruing to participants included use of the loan support program and receipt of certificate payments as a compensation for the required set-aside. In 1972 and 1973 payments were also made for voluntary set-aside above the minimum required.

Though the diversion and set-aside programs may appear quite similar, there is a significant difference between them. While the diversion program idled wheat allotment acres, the set-aside program idled acres from total cropland on the farm as a unit. Because of this, it may be hypothesized that the diversion and set-aside programs had differing impacts upon acreage planted to wheat, with diversion having the larger relative effect.

Though the Government policies considered apply to all wheat, there is a basis for an additional distinction between fall and spring planted wheat. Farmers planting winter wheat have the option of declaring certain acres, seeded to wheat in the fall, to be diversion or set-aside during the following spring. Hence, fall planted acres that are damaged by weather or disease are often classified as diversion or set-aside. Winter wheat regions may thus show a large diversion or set-aside acreage without a corresponding decrease in planted acreage. No such option is generally available to the spring planting producers, who decide at planting time their planted and set-aside acreages. Therefore, it is hypothesized that each acre of diversion or set-aside in the spring wheat areas reduces planted acres to a greater extent than a similar idle acre in the winter wheat areas.

Statistical Models and Data Used

The hypothesized structure for the statistical model includes the influences of five factors on the acreage planted to wheat: (1) the national acreage allotment, (2) acres diverted for payment through 1970, (3) set-aside acres in 1971-73, (4) relaxation of allotment restrictions, and (5) the average market price of wheat during the preceding season.

The timing of passage of major farm legislation and the announcement of various annual options has also been critical in influencing the impact of these programs on acres planted. In some cases, new programs were announced after substantial portions of the wheat crop were already planted. Therefore, the hypothesized model takes into account the timing of passage of the legislation and announcement of options. Likewise, separate estimates are made for spring wheat States and winter wheat States to recognize the differing impacts of the programs under these circumstances.

The functional form selected for the predictive model is linear in both parameters and variables:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + e$$

where

Y = acres planted to wheat (1,000 acres)

X_1 = U.S. wheat acreage allotment (1,000 acres)

X_2 = optional or additional diversion of allotment acres under the diversion programs (1,000 acres)

X_3 = total acres of wheat set aside under the set-aside program (1,000 acres)

X_4 = average price received by farmers for wheat during the previous season (constant 1967 dollars)

X_5 = dummy variable representing the change in the model structure accompanying removal of acreage allotments

X_6 = dummy variable representing the removal of marketing quota penalties from the allotment program and allowing substitution of wheat for feed grains

e = stochastic error term.

Data used for the models come from published U.S. Department of Agriculture sources (*11*) and cover the period 1961-74 (table 1). Experience prior to 1961 is of little value in improving model estimates because only one of the program variables considered, the wheat acreage allotment, was in effect during this period and the allotment was fixed at 55 million acres. Such experience is considered by including 1961 in the analysis.

Special explanation of several of the variables and relationships is useful to understand the model. For 1961-70, acreage allotments were allocated to participating wheat producers. These allotments served as upper limits for producer plantings and are represented by the variable X_1 in table 1. For 1962 the allotment is adjusted downward to 49.5 million acres, the announced 55-million-acre national allotment less a 10 percent mandatory diversion required in that year. Beginning with the implementation of the set-aside program in 1971, acreage allotments were no longer used as a limit for wheat plantings and a zero value is given to X_1 for these years. A dummy variable X_5 is

Table 1. Data used in estimation of regression equations

Year	Acres planted Y	Wheat allotment X_1	Additional diversion X_2	Wheat set-aside X_3	Lagged price X_4	No allotment X_5	Relaxed allotment X_6
		1,000 acres			Dol.		
All wheat:							
1961	55,707	55,000	0	0	1.96	0	0
1962	49,274	[a]49,500	[b]6,125	0	2.04	0	0
1963	53,364	55,000	7,200	0	2.25	0	0
1964	55,672	53,200	776	0	2.02	0	0
1965	57,361	53,300	2,356	0	1.47	0	1
1966	54,105	51,500	1,939	0	1.43	0	1
1967	67,264	68,200	0	0	1.68	0	1
1968	61,860	59,300	0	0	1.39	0	1
1969	53,450	51,600	4,311	0	1.19	0	1
1970	48,739	45,500	3,639	0	1.13	0	1
1971	53,810	33,670	0	3,870	1.14	0.26	0.74
1972	54,896	0	0	20,106	1.10	1	0
1973	59,008	0	0	7,240	1.41	1	0
1974	[c]70,077	0	0	0	2.93	1	0
Winter wheat States:[d]							
1961	41,118	40,159	0	0	1.95	0	0
1962	36,450	[a]36,043	[b]4,502	0	2.00	0	0
1963	40,173	40,017	5,160	0	2.21	0	0
1964	41,671	39,216	714	0	2.00	0	0
1965	42,676	39,309	1,883	0	1.45	0	1
1966	40,444	37,900	1,819	0	1.41	0	1
1967	50,450	50,217	0	0	1.68	0	1
1968	45,311	43,656	0	0	1.36	0	1
1969	39,425	37,983	3,482	0	1.15	0	1
1970	35,678	33,490	2,806	0	1.10	0	1
1971	35,984	33,670	0	0	1.12	0	1
1972	39,571	0	0	12,857	1.11	1	0
1973	41,169	0	0	2,780	1.36	1	0
1974	[c]48,215	0	0	0	2.71	1	0
Spring wheat States:							
1961	14,589	14,841	0	0	2.03	0	0
1962	12,824	[a]13,457	[b]1,623	0	2.37	0	0
1963	13,191	14,983	2,040	0	2.37	0	0
1964	14,001	13,984	62	0	2.12	0	0
1965	14,685	13,991	473	0	1.53	0	1
1966	13,661	13,600	120	0	1.49	0	1
1967	16,814	17,983	0	0	1.71	0	1
1968	16,549	15,644	0	0	1.49	0	1
1969	14,025	13,617	829	0	1.32	0	1
1970	13,061	12,010	833	0	1.24	0	1
1971	17,826	0	0	3,870	1.25	1	0
1972	15,325	0	0	7,249	1.09	1	0
1973	17,839	0	0	4,460	1.52	1	0
1974	[c]21,862	0	0	0	3.37	1	0

[a]Announced wheat allotment of 55 million acres reduced by the mandatory diversion requirement of 10 percent that existed for farmers participating in the program.

[b]Total diversion less the mandatory diversion estimated as 11.11 percent of the participating allotment.

[c]Total of winter wheat from the December 1973 Winter Wheat Report and spring wheat from Prospective Plantings, January 1974.

[d]Winter wheat States include all States except North Dakota, South Dakota, Minnesota, and Montana.

incorporated in the model to account for the normal or equilibrium level of wheat planting in those years in which there was no limiting wheat acreage allotment.[2]

As defined in the model, the X_2 variable represents the diversion of allotment acreage only, thereby reducing a participating farmer's limit on wheat planting to his allotment less this optional (additional) diversion. It was hypothesized that this more restrictive definition of diversion would better explain changes in wheat acreages for years in which a wheat allotment was in effect. Thus the diversion shown in table 1 represents only those acres of allotment voluntarily diverted for payment. Since published data for 1962 also include the mandatory diversion required of all participants, it was necessary to subtract the estimated mandatory diversion from the published value to estimate X_2 for this year.

Variable X_4 is the previous year's season average price received by farmers in constant 1967 dollars.[3] Although use of the previous year's price implies a rather naive farmer price expectation process that may not apply equally to both spring and winter wheat, such price data are readily available. Also, the use of separate methods of representing price expectations for the different types of wheat would destroy the direct comparability of results, as will be discussed later.

Finally, the dummy variable X_6 represents a hypothesized shift in planted acreage during the allotment program resulting from removal of marketing quota penalties and allowing wheat to be planted on the feed grain base. During 1961-63, marketing quota penalties required that overplanting producers pay the Federal Government between 45 and 65 percent of the parity price per bushel on as mush as twice the normal yield for any nonallotment acres planted, and also made them subject to reductions in future allotments as penalties for noncompliance. Although the marketing quota penalty was removed in 1964, the provision for loss of allotment history was retained and deterred plantings to some extent. Beginning with 1965 this penalty was also terminated and a substitution provision made available to wheat producers, allowing them to plant wheat on their feed grain base. Dummy variable X_6 was given a value of one during 1965-70 to recognize these relaxations in allotment restrictions, and was given a value of zero for all other years.

Separate models were estimated for winter wheat, spring wheat, and all wheat. Table 1 shows the data used for the different categories. Data for diversion and set-aside are available for individual States but are not available by winter and spring wheat subgroups. Therefore, all wheat in the major spring wheat producing States was used to represent the spring wheat region. The four States with the largest acreages of spring wheat—North Dakota, Minnesota, South Dakota, and Montana—were thus defined as spring wheat States for the purpose of estimating the spring wheat submodel.

The data for 1971 require special explanation. Since the Food and Agriculture Act of 1970 was not passed until November 1970, long after the date when winter wheat had been planted, only the spring wheat farmers (approximately 26 percent) had an opportunity to adjust planting decisions in accordance with the provisions of the new act. Therefore the 1970 allotment was assumed for estimation of the model in the winter wheat States for 1971 (table 1), in accordance with the hypothesis that winter wheat farmers expected a continuation of the previous program. No allotment was included in the 1971 data for spring wheat States, where farmers had full knowledge of the new set-aside program at planting time. The 1971 set-aside acreage for all wheat includes the set-aside for the spring wheat States only. Finally, the dummy variables X_5 and X_6 take correspondingly different values for spring wheat and winter wheat in 1971. For all wheat, these variables become the weighted average of spring and winter wheat, that is, 0.26 for X_5 to denote removal of the allotment from 26 percent of the wheat and 0.74 for X_6 to denote the relaxed version of the allotment for winter wheat.

Analysis of Results

Results of the estimated regression equations are shown in table 2. The top portion of the table lists results of the final equations selected for predictive purposes. The lower section of the table presents regression results applicable to the objective of measuring the set-aside impact.

The estimated coefficients have the expected signs when compared to the results of similar studies (*1, 8, 9, 10*). For the first three predictive equations, the R_2 values are in the neighborhood of 98 percent and the standard error of the estimate is less than 1 million acres. The standard errors of the individual regression coefficients are generally small in comparison to the coefficients themselves. Using the traditional F-test, all of the coefficients except for set-aside are significant at the 0.01 level in equation (1) for all wheat.[4] The coefficients in the remainder of the equations are generally significant at least at the 0.05 level.

[2] Independent variables that are in effect during only part of the years analyzed need to be accompanied by a zero-one dummy variable to avoid biasing the regression coefficient estimate with data from other years. For example, see (*8*, p. 328).

[3] Prices were adjusted on the basis of the consumer price index. While there are arguments in favor of using the index of prices paid by farmers for this purpose, the high correlation between the two indexes and the nature of the farm firm-household relationship suggest no clear advantage for either.

[4] The standard F-tests for significance used here may tend to overstate the reliability of these coefficients, particularly the regression coefficient for set-aside, $\hat{b}_3$. Since only 4 years of set-aside data are used in estimating the coefficient, it appears intuitively that less than the standard degrees of freedom should be used in the F-test. However, the authors were unable to determine the appropriate degrees of freedom to use in such cases.

Table 2. Summary of regression results from 1961-74 U.S. wheat data

Equation number	Dependent variable $\hat{Y}$	Constant $\hat{a}$	Wheat allotment $\hat{b}_1$	Additional diversion $\hat{b}_2$	Wheat set-aside $\hat{b}_3$	Lagged price $\hat{b}_4$	No allotment $\hat{b}_5$	Relaxed allotment $\hat{b}_6$	Equation F	R_2	Standard error of estimate	Price elasticity
Estimates for the full model:												
1	All wheat	14,035.96	.55393 (.06364) ***	−.68014 (.14004) ***	−.19624 (.12531)	6,002.75 (1,279.85) ***	38,236.86 (4,131.41) ***	5,870.30 (1,093.94) ***	87.2	98.7	953.0	0.17
2	Winter wheat States	3,948.91	.69085 (.06664) ***	−.37119 (.15035) *	−.05050 (.12456)	4,912.43 (953.49) ***	30,793.84 (2,961.82) ***	4,237.91 (850.08) ***	63.0	98.2	790.4	0.19
3	Spring wheat States	5,300.46	.57376 (.11559) ***	−.68841 (.26117) *	−.78820 (.21460) ***	349.97 (598.88)	15,349.82 (2,090.81) ***	940.65 (539.28)	58.2	98.0	479.5	0.04
Price impact removed from data:												
4	All wheat	15,479.28	.62219 (.06366) ***	−61239 (.16081) ***	−.41326 (.07799) ***		43,453.08 (3,825.59) ***	4,089.61 (757.34) ***	61.2	97.4	1,127.3	0.10
5	Winter wheat States	5,367.80	.77355 (.07447) ***	−.30497 (.19126)	−.28472 (.10681) *		34,685.25 (3,256.34) ***	2,580.03 (674.27) ***	36.9	95.8	1,021.9	0.10
6	Spring wheat States	4,791.43	.53303 (.10391) ***	−.75294 (.24632) **	−.62066 (.09127) ***		14,268.90 (1,650.61) ***	1,304.72 (332.19) ***	64.3	97.6	472.0	0.10

Numbers in parentheses below the coefficients are standard errors.
Significance of the coefficients is indicated by the following convention: *.05, **.025, ***.01.

Note the differences between the coefficients in table 2 when all wheat is separated into the winter wheat and spring wheat subsets. The set-aside coefficient, though not significant in the winter wheat areas, is quite significant in the spring wheat region. This result, coupled with the lower coefficient value for diversion in the winter wheat as contrasted to the spring wheat equation, lends support to the hypothesized less precise relationship of set-aside and diversion to planted acreage in the winter wheat areas. On the other hand, the price coefficient is very significant in the winter wheat equation but is not significant in the spring wheat equation. An explanation of this outcome is found in considering the multicollinearity between the two variables.

Regression equations (1), (2), and (3) exhibited symptoms of high multicollinearity between the set-aside and price variables. Although the equations can be considered satisfactory for predictive purposes, they provide little toward meeting the second objective of this study—that is, obtaining an estimate of the true set-aside impact. For 1971-74, when the set-aside program was in effect, set-aside and the lagged price have a very high correlation.[5] When equations (1), (2), and (3) were recomputed omitting set-aside (or price), the price (or set-aside) regression coefficients varied considerably. Since the other characteristics of the equation remained virtually unchanged, multicollinearity between the set-aside and price variables is further indicated by this result. In such a situation, the $\hat{b}$ estimates for the variables involved are suspect and the available statistical tests for significance generally overstate their accuracy.

Statistical theory suggests three alternative techniques for overcoming such problems: (a) the use of additional observations, (b) use of other functional forms omitting one of the variables, or (c) utilizing exogenous or a priori information to estimate one of the variables (*7*). For this analysis, the third technique represents the only practical alternative.

Since the objective of this study was to provide a first estimate of the set-aside coefficient, it was decided to use an a priori estimate of the impact of the price variable. Other studies of short-run price elasticity of wheat acreage response have estimated values in the range of 0.10 to 0.20 (*2*, *3*). A value of 0.10 was selected for this analysis because this value represents, as closely as any, what could be considered a consensus as to the true elasticity.

The regression coefficients for price implied by an elasticity of 0.10 were then computed. The resulting coefficients were multiplied by the price variable X_4 in table 1 and this quantity was subtracted from the dependent variable, acres planted. Data for these revised

[5] This result may suggest that policymakers follow the "cobweb" response hypothesis by declaring a high set-aside acreage in years following a low price and a low set-aside following a year with high prices.

Table 3. Revised acreage data with a priori price impact removed[a]

Year	All wheat	Winter wheat	Spring wheat
		1,000 acres	
1961	48,977	36,131	12,826
1962	42,270	31,335	10,766
1963	45,639	34,521	11,133
1964	48,736	36,556	12,160
1965	52,314	38,968	13,356
1966	49,195	36,838	12,367
1967	61,496	46,153	15,329
1968	57,087	41,833	15,255
1969	49,364	36,484	12,879
1970	44,859	32,865	11,984
1971	49,896	33,120	16,740
1972	51,119	36,732	14,378
1973	54,167	37,691	16,519
1974	60,017	41,284	18,935

[a] Each of the revisions is based on a wheat acreage price elasticity of 0.10.

dependent variables are shown in table 3.[6] The adjusted acres planted were regressed on the same variables as the original equations (excluding the price variable) to obtain the adjusted regression equations shown as equations (4), (5), and (6) in table 2.

The estimates for b_3 in the second set of regression equations appear reasonable, are close to the levels expected, and are significant statistically. Again the contrast between the diversion and set-aside coefficients and the winter and spring wheat areas is noteworthy. In both equations, the set-aside coefficient is of a smaller magnitude than that for the diversion variable, reflecting a smaller impact in reducing acreage planted to wheat. Similarly, coefficients for both variables in the winter wheat equation are smaller than those in the spring wheat equation, again verifying the smaller impact of these programs on winter wheat producers' fall planting decisions.

Performance of the model is demonstrated by figure 1, which shows the actual acreage of all wheat planted as well as the estimated acreage based on equation (1). The equation (1) estimate for 1975 is also shown, assuming a 1974 season average price of \$4 (equivalent to \$2.71 in

[6] For the linear form of a regression equation, the formula for elasticity is $\epsilon = bX/Y$. Evaluated at the means, the formula becomes $\epsilon = b\bar{X}/\bar{Y}$ or $b=\epsilon\bar{Y}/\bar{X}$. In this example, the all-wheat coefficient implied by an elasticity of 0.10 is calculated at $b_4 = 0.10 \times 56751.21/1.65286$ or $b_4 = 3433.52$.

Multiplying the price for each year by this coefficient and then subtracting from the dependent variable yields a revised dependent variable with the estimated price impact removed. For example, the revised dependent variable for all wheat in 1961 is computed as follows: $55707 - 3433.52 \times 1.96 = 48977$. The other coefficients computed similarly were b_4 (winter wheat) = 2557.56 and b_4 (spring wheat) = 868.48.

U.S. wheat acreage planted, actual and estimated

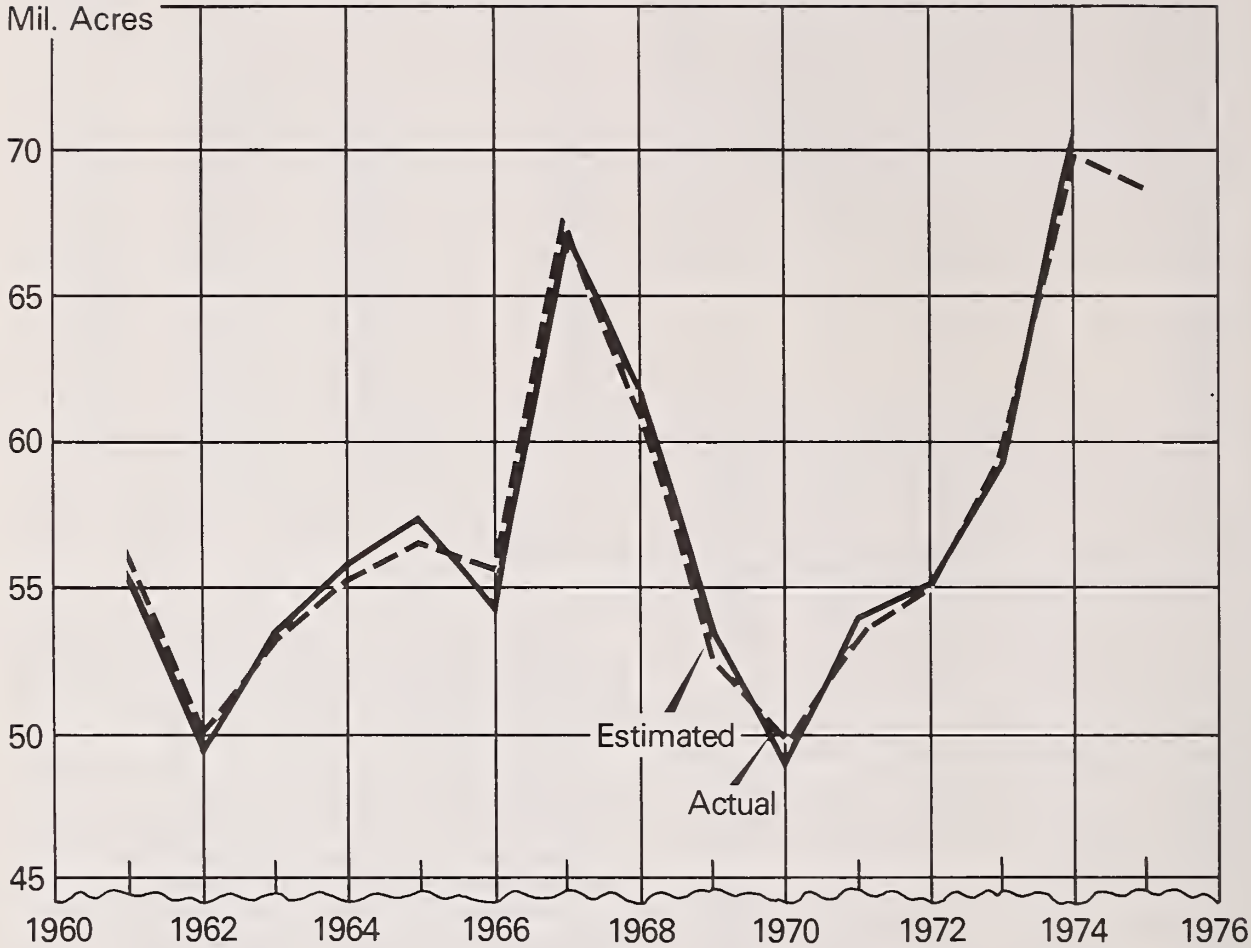

Figure 1

constant 1967 dollars) and no set-aside requirement. The 1975 estimate of 68.5 million acres is 1.5 million acres lower than the 1974 intended acreage of 70 million acres.

Summary

Regression results from the six equations indicate that for 1961-70 each acre of additional diversion under the Government wheat program reduced total wheat plantings by about 0.61 acre. For 1971-74 each set-aside acre of wheat reduced acreage planted to wheat by about two-thirds of that for the diversion programs, about 0.41 acre per acre set aside.

For the winter wheat region, the set-aside and diversion programs have been about equally effective in reducing planted acres. In this region, a reduction of somewhat less than one-third acre in plantings has been associated with 1 acre of diversion or set-aside. In the spring wheat regions, the wheat set-aside program has been slightly less effective than the diversion programs. However, in the spring wheat region both programs have had more than double the impact they have had in the winter wheat region, with each acre of diversion reducing plantings by about 0.75 acre and each acre of set-aside reducing plantings by about 0.62 acre. Over the historical period analyzed, the diversion programs were more effective than the set-aside programs in reducing acreage planted to wheat.

In conclusion, the hypothesized models fit historical data well and reasonable estimates of the set-aside impact are obtained. However, as with the use of most models of this type, predictions of future impacts should be examined with some skepticism, particularly when they rely on data outside the range of that used in the regressions.

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Setting Loan Support Rates for Major Feed Grains

By R. C. Kite and P. D. Velde

A multicommodity, multiregional linear programming model is employed to obtain price differentials between 16 U.S. regions for corn, barley, grain sorghum, and oats. The price differentials are used to obtain loan support rates (for the 1974 crop) in each region, for each grain, so that relative feeding values, transport rates, and supply and demand conditions are an integral part of the loan rate structure.

Keywords: Linear programming, price differentials, loan support rates, corn, barley, oats, sorghum.

The multiregional, multicommodity linear programming model described in this paper is used as an aid for establishing loan support rates for four major feed grains: corn, barley, grain sorghum, and oats. The paper is presented in three sections. The first is an overview of the loan provisions of the Agriculture and Consumer Protection Act of 1973 (which provides authority for support activities related to the 1974 crop).[1] The second section presents the mathematical framework of the linear programming model. The third section presents the empirical model and its solution.

Loan Provisions for 1974 Feed Grain Crop

The 1973 Agriculture and Consumer Protection Act, like preceding acts, provides for direct purchase, purchase agreements, set-aside payments, and nonrecourse loans for specified agricultural commodities. The three methods of support (purchase, payments, and loans) are interdependent in actual operation of the support program (*5*, p. 19). Since this paper focuses on the establishment of loan rates, the interdependencies can be ignored.

The Secretary of Agriculture is given the responsibility and authority to set loan rates, subject to legislated limits and guidelines. Eight factors which must be considered are specified by Section 401(b) of the 1949 Agricultural Act. The factors are (*5*, p. 3):

1. The supply of the commodity in relation to the demand;
2. The price levels at which other commodities are being supported and, in the case of feed grains, the feed values of each grain in relation to corn;
3. The availability of funds;
4. The perishability of the commodity;
5. The importance of the commodity to agriculture and the national economy;
6. The ability to dispose of stocks acquired through a price support operation;
7. The need to offset temporary losses of export markets; and
8. The ability and willingness of producers to keep supplies in line with demand.

The 1973 Act places additional restrictions on the loan rates to be established. The national average loan rate for corn is limited to a minimum of $1.10 per bushel and must not exceed 90 percent of parity. The support levels for all grains are to be set by the Secretary at points considered reasonable in relation to the corn rate, taking into consideration feeding values and transportation rates relative to corn (*5*, p. 19). Loan rates to individual producers reflect the national average rate, as determined by the Secretary, with adjustments for grain quality and location.

Consideration of all the specified factors represents a problem of some magnitude. The statutory requirements are such that an informal method for setting loan rates is unlikely to satisfy all necessary conditions simultaneously. An advantage of the mathematical programming model presented in the following section is that it provides a formal structure, with flexibility to incorporate alternative supply, demand, and transportation situations while taking account of the use of the grains in animal feeding.

A Model

The model is constructed to provide estimates, subject to given data, of the allocation of grains between domestic regions and from the domestic regions to export points. The domestic interregional grain movements are generated to satisfy regional feed and export requirements at each specified point.

[1] The Federal Government has engaged in some form of commodity price support activity since 1929, when the Agricultural Marketing Act established the Federal Farm Board (*3*, p. 69). Nonrecourse commodity loans were initiated in 1933 when the Commodity Credit Corporation was created (5, p. 1). Price support operations are conducted primarily by the Commodity Credit Corporation.

For this presentation we assume that a perfectly operating national pricing system exists, and that the transportation system does not use resources employed by the animal feeding sector, so it will be appropriate to seek a national objective of minimum transportation costs. This formulation enables us to obtain regional feed and grain price differentials, as well as interregional flows of grains. The price differentials may then be used to impute regional loan rates for the feed grains. The model is cast in a linear programming framework and consists of four major components:

1. Regional grain supplies, which are assumed to be known in both location and quantity.
2. An export component, for which we assume known export quantities from specific points of debarkation and fixed point-to-point transport costs from domestic points to debarkation points.
3. A domestic transport component, for which point-to-point unit transport costs are known and fixed.
4. An animal feeding component consisting of sets of alternative feed rations, for various types of animal feeds in each domestic region. Total feed requirements are assumed to be known for each feed in each region.

Figure 1 gives an overview of the linear programming model. A mathematical representation is shown in relations (1) to (7) below. (See (*2*) for a more complete discussion of the model).

Define:

t_j^{ik} = Transport cost of grain j from region k to region i

y_j^{ik} = Quantity of grain j transferred from region k to region i

w_r^i = Lagrangian multiplier relating the value of feed r to region i

U_j^i = Lagrangian multiplier relating the value of grain j to receiving region i

U_j^k = Lagrangian multiplier relating the value of grain j to shipping region k

f_{jr}^{li} = Proportion of grain j used in process l to produce feed r in region i (i.e., f_{jr}^{li} for $j = 1, J$ represents the lth feed ration of type r in region i)

A_r^{lk} = Intensity of process l in producing feed r in region k

X_j^k = Fixed quantity of grain j available in region k

Q^{ir} = Quantity of feed r required in region i

E_j^i = Quantity of grain j exported from export point i

I = Number of receiving regions, where the first I' regions are domestic points and the rest $(I\text{-}I')$ are export points

K = Number of shipping regions

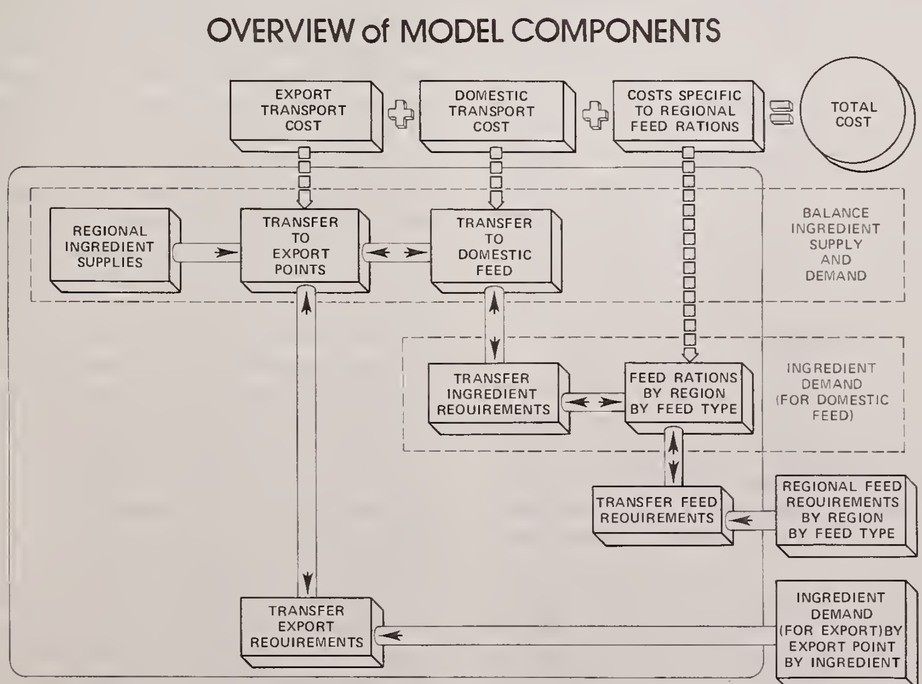

Figure 1

J = Number of grains

R = Number of feed commodities

L = Number of processes.

We wish to minimize total transfer cost:

$$(1) \quad \sum_{i}^{I} \sum_{k}^{K} \sum_{j}^{J} t_j^{ik} \; y_j^{ik}$$

This objective is to be attained subject to four conditions:

Quantity of feed r produced in region i must at least equal that region's requirement for the feed:

$$(2) \quad Q^{ir} \leq \sum_{l}^{L} A_r^{li}, \quad r = 1, R; i = 1, I'$$

Shipments of grain j from region k must not exceed that region's initial supply of the grain:

$$(3) \quad \sum_{i}^{I} y_j^{ik} \leq X_j^k, \quad k = 1, K; j = 1, J$$

Receipts of grain j by region i must at least equal the amount used for feed:

$$(4.1) \quad \sum_{l}^{L} \sum_{r}^{R} A_r^{li} \; f_{jr}^{li} \leq \sum_{k}^{K} y_j^{ik},$$

$$i = 1, I'; j = 1, J$$

and the amount shipped to export points.

$$(4.2) \quad E_j^i \leq \sum_{k}^{K} y_j^{ik}, \; i = I'+1, \; I \text{ and } j = 1, J$$

(5) All y_j^{ik} and A_r^{li} nonnegative.

Conditions for the minimization of (1) subject to (2), (3), (4), and (5) yield the usual information:

(1) If it is possible for a region to produce more feed than it needs, the implicit value of the feed in that region will be zero.

(2) If a grain supplying region, after all requirements are met, has surplus grain, the implicit value (U_j^k) of that grain in that region is zero. The U_j^k represent the prices which would maximize the value of supplies in each supplying region (considering only transportation costs). In this context, the U_j^k are a set of interregional price differentials which establish an equilibrium between grain supply and demand. They may also be interpreted as interregional loan rate differentials which would least disturb the allocation of grains for use in animal feeds. That is, these differentials reflect the value of the grains, taking into consideration the supply of grains, export demand, feed demand, and the relative feeding values of the grains in conjunction with transportation rates. In addition, the U_j^i are zero if total grain availability in a given demanding region exceeds its needs. When i and k are the same region, $U_j^i = U_j^k$. The U_j^i are equilibrium prices for the grains in the demanding regions. These data are not discussed in this report but they do have usefulness in determining competitive positions for grain supplying regions.

The model as constructed and the LP algorithm insure that the relationship between the grain supply and demand is rigorously maintained. It further insures that transportation rates are a fundamental element in determining relative values for the grains. The structure of the model also insures (through the feed rations) that the nutritional characteristics of all included grains are a significant determinant of the (imputed) values. The model, then, accounts for some, but not all, of the eight factors specified for consideration by Section 401(b) of the 1949 act and by the 1973 act. Specifically, the price differentials obtained will depend upon grain supply relative to demand, transportation rates, and the regional mix of animal and feed grain production.

Loan Support Rates for 1974/75 Crop

The empirical model used to generate loan price differentials contains 16 domestic regions and nine export points (appendix tables A-1 and A-2). In total, 16 different feeds are included in the model, several each for beef, dairy, pork, poultry, and sheep. (Specifications of the feeds are given in appendix table A-3.) The model contains several different rations for each feed type. Least-cost, linear programming formulation was used to obtain each alternative ration. The formulation model contained 22 ingredients in addition to the four grains of interest. (The ingredients are listed in appendix table A-4).

The basic supply and export data used in the model are summarized in table 1. A total of about 221 million tons of the four feed grains were assumed available for use in feed and for export with the remainder available for carryover (industrial, seed, and food uses were subtracted from total supply). The method used to allocate the supplies to individual regions is discussed in the appendix.

Table 1 also shows the model estimates of grain consumption by livestock. Since estimation of grain consumption is not the subject of this paper, we will not pursue this aspect of the model solution. Appendix table A-9 shows estimates of consumption by grain and livestock type.

Table 1. Summary of basic data used in model and model solution, four grains, 1974/75

	USDA estimates[a]				From model	
	Supply available[b]	Export	Consumed by livestock	Surplus	Consumed by livestock	Surplus
			Million tons			
Corn	172.7	32.2	122.5	18.0	114.8	25.7
Barley	8.8	1.8	4.7	2.2	6.9	.1
Sorghum	24.8	5.6	19.0	.1	18.9	.3
Oats	14.4	.5	10.2	3.8	10.9	3.0
Total	220.7	40.1	156.4	24.1	151.5	29.1
Total feed required	—	—	—	—	199.8	—

[a]Source for data is (4). See also appendix table A-5.
[b]Excludes estimates for seed, industrial, and human use.

Results: Price Differentials and Loan Rates

The price differentials resulting from solution of the model are shown in table 2. These differentials display the relationships common to interregional price surfaces. The differentials are high in regions removed from grain supplies and low in regions with large supplies. The price surface is uniformly low in regions 3, 4, 5, 6, and 7. With the exception of grain sorghum, the differentials are high in the remaining regions.

All differentials displayed in table 2 are relative to region 3 (Indiana, Ohio, and Illinois). Thus, the value of 18.1 cents per bushel of corn shown for region 2 (New York, Pennsylvania, and New Jersey) is to be interpreted as meaning the loan rates should be structured so that the rate in region 2 is 18.1 cents per bushel higher than in region 3. Similarly, the rate in region 5 (Iowa, Missouri) should be 3.7 cents per bushel lower than the rate in region 3.

The differentials given in table 2 provide basic information which can be used to establish the level of loan rates. While the differentials are based on basic supply, demand, and transportation conditions, the actual loan levels must be set in the light of additional factors. Some of these factors were mentioned earlier in the paper—the eight factors specified by Section 401(b) of the 1949 Agricultural Act and the specifications of the 1973 Agriculture and Consumer Protection Act. An important additional factor will be Government policy with respect to grain reserves and foreign affairs.

We have assumed that a loan rate of $1.10 per bushel for corn has been determined as the minimum level. Using this level and the differentials shown in table 2, we establish the loan rates shown in column 5 of table 2. The loan rates for corn now retain the appropriate differential relationships with the minimum rates ($1.10) established for regions 4, 5, and 6.

The procedure for establishing the remaining regional loan rates was as follows. We retain region 3 as the base region for which the corn loan rate has been determined exogenously. We then establish loan rates in region 3 for the remaining grains according to the relationship between the corn rate and the feeding value of the other grains relative to corn. This relationship is derived from the result in economic theory which shows that the organization of inputs to produce a given level of output should be such that the rate of technical substitution (*RTS*) is equal to an appropriate price ratio—in this case the ratio of loan rates.

The *RTS* indicates the amount of one input which must replace one unit of another to maintain the appropriate input balance. The *RTS* between, say, corn and barley is defined as the ratio of the marginal products of barley and corn, and this should be equated to the ratio of the barley and corn loan rates.

It is possible to obtain estimates of the *RTS* from an LP model. However, in contrast to the classical derivation of an *RTS*, the LP estimate can (and certainly would) exhibit many different *RTS* values for a given input combination. This is so because the marginal products can be (and usually are) discontinuous. This means the *RTS* obtained from an LP solution may not be a desirable measure of the relative feeding values needed to help specify loan rates.

A more desirable *RTS* can be obtained from a continuous function, preferably one which would specify the *RTS* at various input levels; that is, one which recognizes that the *RTS* is a function of input levels, as well as the output level. We have not followed this procedure. We have, instead, assumed that the *RTS* between corn and other inputs remains constant at all input and output levels.

The *RTS* of barley, grain sorghum, and oats were derived from data available in Hodges (*1*, p. 40). These data give the relative values of the grains compared with corn when fed to various classes of livestock. An aggregate *RTS* was obtained by weighting each value as

Table 2. Price differentials and loan rates for corn, barley, grain sorghum, and oats, 1974/75 crop

Region	Price differentials (U_j^k)				Loan rate with corn minimum at $1.10			
	Corn	Barley	Grain sorghum	Oats	Corn	Barley	Grain sorghum	Oats
	Cents per bushel				*Dollars per bushel*			
1. New England	24.6	18.7	14.9	19.4	1.383	1.053	1.215	0.775
2. New York, Pennsylvania, New Jersey	18.1	10.4	4.5	8.5	1.318	.970	1.111	.666
3. Ohio, Indiana, Illinois	0.0	0.0	0.0	0.0	1.137	.866	1.066	.581
4. Michigan, Wisconsin, Minnesota	−3.7	−10.6	−20.8	−2.6	1.100	.760	.858	.555
5. Iowa, Missouri	−3.7	−.4	−18.5	−1.6	1.100	.862	.881	.565
6. North Dakota, South Dakota	−3.7	−12.5	−20.8	−2.6	1.100	.741	.858	.555
7. Nebraska, Kansas	4.0	−5.6	−14.0	2.2	1.177	.810	.926	.603
8. Virginia, West Virginia, Maryland, Delaware, North Carolina	16.2	9.3	4.0	12.7	1.299	.959	1.106	.708
9. South Carolina, Georgia, Florida	32.1	20.6	16.5	19.3	1.458	1.072	1.231	.774
10. Kentucky, Tennessee	14.2	6.0	−1.7	10.4	1.279	.926	1.049	.685
11. Alabama, Mississippi, Arkansas, Louisiana	21.1	14.2	7.4	19.2	1.348	1.008	1.140	.773
12. Oklahoma, Texas	22.1	10.6	.1	11.5	1.358	.972	1.067	.696
13. Montana, Idaho, Wyoming	45.3	6.8	−1.1	4.2	1.590	.934	1.055	.623
14. Colorado, New Mexico, Arizona, Utah	16.6	4.9	−3.6	10.4	1.303	.915	1.030	.685
15. Washington, Oregon	48.1	44.0	37.8	30.8	1.618	1.306	1.444	.889
16. Nevada, California	57.3	39.9	39.5	42.8	1.710	1.265	1.461	1.009

given by Hodges by the number of grain-consuming animal units (1973) in each class of livestock (7). The resulting *RTS* then reflected both nutritional value and the mix of livestock. The *RTS* derived were as follows:

j	RTS_j (corn for j)	WT_j (lb./bu.)
1 Corn	1.0000	56
2 Barley	.8883	48
3 Sorghum	.9378	56
4 Oats	.8938	32

The *RTS* and the established corn loan rate in region 3 are then combined as follows:

$$(8)\quad L_j^3 = 1.137/56 \times (RTS_j) \times (WT_j), j = 2, 4$$

where

L_j^3 = loan rate for grain j in region 3

WT_j = weight per bushel for grain j

RTS_j = feeding value of grain j relative to corn (grain 1) in region 3

We then establish loan rates for the remaining regions according to:

$$(9)\quad L_j^k = L_j^3 + U_j^k, j = 1, 4; k = 1, 16; k \neq 3.$$

The application of this procedure provides the loan rates given in table 2. This loan rate structure now contains the required balance between regional supply, demand, and the transportation rate structure—taking into account relative feeding values. The differentials between regions, for individual grains, are maintained so that (within the context of the model) the various regions will be indifferent as to source of the grain.

However, the relationships across grains have been disturbed by the procedure, which has introduced a synthetic difference between corn and the other grains in region 3. This difference is then transmitted to the other regions. For corn-barley we have 1.137 – 0.866 = 0.271 in region 3. Taking region 7 as an example, the

total effect of the procedure is 1.177 – 0.810 = 0.367. For region 7 the original differential for corn-barley was $0.096 per bushel, which added to 0.271 gives the 0.367. In other words, the price surface for barley versus corn has been lowered by 27.1 cents per bushel. This shift is due to the assumption that the rates of substitution between grains are the same in all regions. This assumption has been enforced "post solution." An alternative would be to include within the model, perhaps in place of the feed rations, the appropriate regional rates of substitution (by animal type). What we have done is apply an average rate of substitution across all regions. The *RTS* used is not the same as would be devised from the model (for example, the model estimate of the average *RTS* corn for barley is 0.75) but those used are felt to be appropriate.

Summary

A formal structure has been applied to the problem of determining regional price differentials for four feed grains. These differentials are then used to estimate loan support rates. The derived rates satisfy the statutory requirement that supply, demand, transport rates, and relative feeding values be considered when the rates are established. The method presented may be usefully applied to a variety of loan rate situations. In the example presented here we have used a minimum corn support rate of $1.10 per bushel. If it becomes desirable to change the basic support levels, a new loan rate structure can be easily obtained. Naturally, the worth of a new structure would depend upon what factors caused a recalculation to be necessary. If the basic supply, demand, and transportation data used in this study were violated in a new situation, it would be necessary to obtain a new solution for the model.

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Appendix

Origin and destination points and types of feed are shown in tables A-1 to A-4. Data used in the analysis are in tables A-5 to A-8.

Grain supplies. Grains available for feed and export use were developed from estimates of beginning stocks, production, and imports. Estimates of seed, industrial, and food uses of the grains were then subtracted from the total available. Table A-5 shows the U.S. data.

Regional supplies of the grains were than estimated by assuming that the 1974/75 regional distribution would be the same as in 1973. These data are shown in table A-6.

Total feed requirements. Details concerning the method for estimating feed requirements may be found in (*2*). Basically the method was to calculate the quantity of high protein feed needed to pass an animal (or poultry) from one growth stage to another. This method requires estimates of the number of animals on feed, at various stages. For this analysis we estimated the number for the United States and allocated this to regions according to the distribution in 1971. Table A-7 shows the regional distribution of feed requirements.

Export requirements. Estimates of U.S. exports of the feed grains were obtained (A-5) and allocated to export points according to the export distribution in 1971. The allocated export quantities are shown in table A-8.

Transportation rates. Transport costs for point-to-point shipments of the grains were provided by the Agricultural Stabilization and Conservation Service. These rates were effective January 1973.

Table A-1. Domestic regions with origin and destination points

Region	Ingredient	Origin point	Destination point
(1) Maine	Corn	Keene, N.H.	Keene, N.H.
New Hampshire	Barley	Keene, N.H.	Keene, N.H.
Vermont	Sorghum	Keene, N.H.	Keene, N.H.
Connecticut	Oats	Keene, N.H.	Keene, N.H.
Rhode Island			
Massachusetts			
(2) New York	Corn	Oneonta, N.Y.	Oneonta, N.Y.
New Jersey	Barley	Oneonta, N.Y.	Oneonta, N.Y.
Pennsylvania	Sorghum	Oneonta, N.Y.	Oneonta, N.Y.
	Oats	Oneonta, N.Y.	Oneonta, N.Y.
(3) Ohio	Corn	Bloomington, Ill.	Anderson, Ind.
Indiana	Barley	Bedford, Ind.	Bellefontaine, Ohio
Illinois	Sorghum	Centralia, Ill.	Anderson, Ind.
	Oats	Marion, Ind.	Anderson, Ind.
(4) Michigan	Corn	Mankato, Minn.	Mankato, Minn.
Wisconsin	Barley	Detroit Lakes, Minn.	Wisconsin Dells, Wis.
Minnesota	Sorghum	Detroit Lakes, Minn.	Lansing, Mich.
	Oats	Willmar, Minn.	Lansing, Mich.
(5) Iowa	Corn	Ames, Iowa	Ames, Iowa
Missouri	Barley	Waterloo, Iowa	Columbia, Mo.
	Sorghum	Sedalia, Mo.	Columbia, Mo.
	Oats	Waterloo, Iowa	Ames, Iowa
(6) North Dakota	Corn	Valley City, N. Dak.	Mitchell, S. Dak.
South Dakota	Barley	Aberdeen, S. Dak.	Aberdeen, S. Dak.
	Sorghum	Gregory, S. Dak.	Gregory, S. Dak.
	Oats	Huron, S. Dak.	Mitchell, S. Dak.
(7) Nebraska	Corn	Topeka, Kans.	Columbus, Neb.
Kansas	Barley	North Platte, Neb.	North Platte, Neb.
	Sorghum	Great Bend, Kans.	Great Bend, Kans.
	Oats	Norfolk, Neb.	Columbus, Neb.
(8) Virginia	Corn	Rocky Mt., N.C.	Fayetteville, N.C.
West Virginia	Barley	Winston Salem, N.C.	Fayetteville, N.C.
Maryland	Sorghum	Charlotte, N.C.	Fayetteville, N.C.
Delaware	Oats	Durham, N.C.	Fayetteville, N.C.
North Carolina			
(9) South Carolina	Corn	Cordele, Ga.	Macon, Ga.
Georgia	Barley	Macon, Ga.	Macon, Ga.
Florida	Sorghum	Cordele, Ga.	Macon, Ga.
	Oats	Macon, Ga.	Macon, Ga.
(10) Kentucky	Corn	Paris, Tenn.	Murfreesboro, Tenn.
Tennessee	Barley	Nashville, Tenn.	Murfreesboro, Tenn.
	Sorghum	Nashville, Tenn.	Murfreesboro, Tenn.
	Oats	Murfreesboro, Tenn.	Murfreesboro, Tenn.
(11) Alabama	Corn	Hoxie, Ark.	Little Rock, Ark.
Mississippi	Barley	Hoxie, Ark.	Little Rock, Ark.
Arkansas	Sorghum	W. Memphis, Ark.	Little Rock, Ark.
Louisiana	Oats	Pine Bluff, Ark.	Little Rock, Ark.

Continued

Table A-1. Domestic regions with origin and destination points (Continued)

Region	Ingredient	Origin point	Destination point
(12) Oklahoma	Corn	Waco, Texas	Oklahoma City, Okla.
Texas	Barley	Wichita Falls, Tex.	Oklahoma City, Okla.
	Sorghum	Lubbock, Tex.	Lubbock, Tex.
	Oats	Enid, Okla.	Oklahoma City, Okla.
(13) Montana	Corn	Miles City, Mont.	Casper, Wyo.
Idaho	Barley	Havre, Mont.	Casper, Wyo.
Wyoming	Sorghum	—	Casper, Wyo.
	Oats	Lewiston, Mont.	Twin Falls, Idaho
(14) Colorado	Corn	Spring Valley, Ariz.	Denver, Colo.
New Mexico	Barley	Boulder, Colo.	Denver, Colo.
Arizona	Sorghum	LaJunta, Colo.	Provo, Utah
Utah	Oats	Salida, Colo.	Boswell, N. Mex.
(15) Washington	Corn	Bend, Oreg.	Ellensburg, Wash.
Oregon	Barley	The Dalles, Oreg.	Ellensburg, Wash.
	Sorghum	—	Bend, Oreg.
	Oats	The Dalles, Oreg.	Bend, Oreg.
(16) Nevada	Corn	Tracey, Calif.	Fresno, Calif.
California	Barley	Carson City, Nev.	Fresno, Calif.
	Sorghum	—	Fresno, Calif.
	Oats	Carson City, Nev.	Fresno, Calif.

Table A-2. Designated export points for all ingredients

Export point	Location
1	Superior, Wis.
2	Chicago, Ill.
3	Toledo, Ohio
4	Philadelphia, Pa.
5	Norfolk, Va.
6	New Orleans, La.
7	Houston, Tex.
8	San Francisco, Calif.
9	Portland, Oreg.

Table A-3. Feed types used in the analysis

Feed number	Description
1 (Dairy)	Dairy—mature
2	Dairy replacement
3 (Beef)	Beef—700#
4	Beef—above 700#
5	Swine—breeding herd
6 (Swine)	Swine—starter
7	Swine—grower
8	Swine—finish
9	Chickens—layers
10	Chickens—raised to 6 weeks
11	Chickens—raised to finish
12 (Poultry)	Turkeys—breeding
13	Turkeys—0-6 weeks
14	Turkeys—6-18 weeks
15	Turkeys—18+ weeks
16 (Sheep)	Sheep—fed/on feed

Table A-4. Ingredients

Ingredient number	Ingredient description
Included directly:	
1	Corn
2	Barley
3	Sorghum
4	Oats
Included indirectly:	
5	Wheat
6	Rye
7	Soybean meal
8	Cottonseed meal Ex. 41
9	Cottonseed meal S. 41
10	Cottonseed meal Ex. 44
11	Fishmeal Her.
12	Fishmeal Men.
13	Fishmeal Per.
14	Corn gluten meal
15	Corn gluten feed
16	Corn fermented solubles
17	Meat meal 55
18	Meat and bone meal 50
19	Feather meal
20	Poultry byproduct
21	Animal fat
22	Vegetable and animal fat
23	Cane molasses
24	Urea
25	Dry skim milk
26	Dry whey

Table A-5. Estimated U.S. aggregate supplies available for feed, export, and carryover for corn, barley, grain sorghum and oats, 1974/75 crop year

Item	Corn	Barley	Grain sorghum	Oats	Total
			1,000 tons		
Beginning stocks	12,684	3,216	2,128	4,176	22,204
Production	172,200	8,928	22,876	11,712	215,716
Imports	28	360	0	32	420
Total available	184,912	12,504	25,004	15,920	238,340
Food, industrial, seed	12,180	3,744	224	1,488	17,636
Expected carryover	18,032	2,184	140	3,760	24,116
Expected exports	32,200	1,844	5,600	480	40,124
Expected feed use	122,500	4,656	19,040	10,192	156,388
Available for carryover, feed, export	172,732	8,760	24,780	14,432	220,704
Available for feed and export	154,700	6,576	24,640	10,672	196,588

Source: Derived from (4).

Table A-6. Estimated regional distribution of feed grain production, 1974/75 crop

Region	Corn	Barley	Sorghum	Oats
		1,000 bushels		
1	0.0	0.0	0.0	2,125.1
2	125,458.9	6,993.4	0.0	48,585.3
3	1,935,640.9	1,220.9	6,000.3	79,115.3
4	896,781.3	36,032.1	0.0	292,763.0
5	1,566,531.1	369.0	30,897.1	88,308.5
6	166,273.0	107,754.6	10,645.7	236,933.7
7	763,092.9	3,842.0	338,734.6	35,435.1
8	245,464.5	11,145.6	5,023.3	10,682.4
9	129,462.6	1,286.3	1,648.8	9,204.0
10	130,499.0	2,016.3	2,682.4	2,261.3
11	40,770.9	0.0	9,135.0	7,566.9
12	75,027.4	9,686.4	422,968.9	47,016.7
13	6,033.3	94,327.7	—	21,125.7
14	52,214.4	26,170.9	38,280.7	3,422.2
15	8,766.1	22,288.0	0.0	11,060.3
16	26,977.0	41,866.9	18,983.2	6,394.3
Total	6,169.000.0	365,000.0	885,000.0	902,000.0

Table A-7. Estimated regional feed requirements, by type of livestock, 1974/75

Region	Dairy	Beef	Swine	Poultry	Sheep	Total
			Million tons			
1	0.84	0.00	0.09	1.47	0.00	2.40
2	3.43	.54	.64	2.67	.02	7.29
3	1.94	4.17	12.45	2.75	.23	21.53
4	6.63	4.21	5.61	3.13	.49	20.06
5	1.54	11.09	17.58	1.69	.25	32.15
6	.61	2.87	2.39	.39	.32	6.58
7	.67	17.42	5.00	.55	.36	23.99
8	1.08	0.00	2.37	6.11	0.00	9.57
9	.82	0.00	2.09	6.38	0.00	9.29
10	1.14	0.00	1.86	.84	0.00	3.83
11	1.03	0.00	1.60	10.07	0.00	12.70
12	1.01	12.66	1.29	2.48	.56	18.00
13	.42	2.03	.41	.02	.51	3.40
14	.50	10.92	.50	.42	1.05	13.39
15	.58	1.40	.17	.83	.17	3.15
16	1.71	6.37	.16	4.05	.21	12.50
Total	23.95	73.66	54.20	43.84	4.17	199.83

Table A-8. Estimated regional distribution of feed grain exports, 1974/75

Region	Corn	Barley	Sorghum	Oats
	1,000 bushels			
1	100,881.5	0.0	0.0	0.0
2	81.625.8	30,767.8	0.0	25,750.6
3	87,462.7	0.0	0.0	0.0
4	53,237.0	0.0	0.0	0.0
5	102,014.7	0.0	0.0	0.0
6	704,398.5	2,785.9	11,342.4	4,249.4
7	20,379.6	3,150.7	179,019.8	0.0
8	0.0	0.0	9,637.8	0.0
9	0.0	43,295.6	0.0	0.0
Total	1,150,000.0	80,000.0	200,000.0	30,000.0

Table A-9. Model solution: Estimated feed ingredient use by specified types of livestock, United States, 1974/75

Ingredient	Dairy	Beef	Swine	Poultry	Sheep	Total
	1,000 tons					
Corn	12,137.6	40,775.8	36,805.6	22,113.0	2,957.7	114,789.7
Barley	11.9	2,572.6	2,173.5	1,144.3	1,013.3	6,915.6
Sorghum	2,190.6	11,982.8	1,829.5	2,943.0	0.0	18,945.9
Oats	538.8	2,347.3	5,175.4	2,792.9	0.0	10,854.4
Total	14,878.9	57,678.5	45,984.0	28,993.2	3,971.0	151.505.6
Other ingredients	9,071.1	15,981.5	8,216.0	14,846.8	199.0	48,314.4
Total feed ingredient	23,950	73,660	54,200	43,840	4,170	199,830

BOOK REVIEWS

Social Indicators and Social Theory: Elements of an Operational System

By Karl A. Fox. A Volume in the Wiley Series in Urban Research, edited by Terry N. Clark. John Wiley and Sons, Inc., 605 Third Avenue, New York 10016. 328 pages. 1974. $14.95.

The author implicitly assumes that our societies (however defined, aggregated, or disaggregated) are so important to us that we ought to know more about them. They are so important, in fact, that we should be able to make formal accounting statements of resources, inputs, and outputs, and to make better informed judgments about social performance, much as we do about the economy (which is a part of society). And we should have a meaningful set of social indicators with which to monitor social well-being and social progress.

Toward this end, Fox then observes that there is significant, and perhaps sufficient, social theory already available and a large amount of data already being collected. The real point of the book, I think, is to plead for the development of method so that the relationships of indicators to each other can be examined in a framework of social accounts reflecting, in the aggregate, an integrated social perspective. Fox supports this contention by pointing out what the development of the National Income Accounts did for the selection and interpretability of economic indicators.

To add method and system to social measurement, Fox characterizes social operations in a manner analogous to economic operations. Abstracted from most complexities, behavior settings are characterized as markets, or production or consumption sites. Then what is needed is an "envelope" measure of an individual's social activity. In Fox's words:

> In this book I have proposed the concept of an individual's total income and have made some suggestions regarding how it might be measured. The equivalent dollar values of total incomes can be aggregated over individuals to yield estimates of total income for families, communities, regions, and nations. These total incomes are estimates of the "boundaries," so to speak, of the respective social systems.
>
> Within such a boundary, the relationship of various social indicators to one another can be appraised and models of various subsystems can be interpreted in relation to the whole . . ." (pp. 257-258).

Most of the actual discussion in the book argues that the measurement and analytical system proposed are generally applicable—with illustrations in terms of institutions and societies of various kinds, locations, and levels of aggregations.

This is an ambitious book, and one must keep his wits about him to keep from getting lost in it. I think the author recognized this, and provided two road maps—one at the beginning and one at the end. The one at the end, chapter XIV, was the more useful for me.

Any person seriously concerned with describing and analyzing human behavioral systems should read the book. Perhaps it tries to organize more than can be organized and digested at this time, and the proposals it contains are bound to be controversial. It will, for example, be interesting to observe the reactions of social scientists from other disciplinary fields to an economist who asks "why can't you be more like me," and then offers a methodological gambit which amounts to a direct challenge. Fox's proposals, if acceptable, would indeed render the metrics of other human behavioral systems and institutions similar to those used in economics.

The construction of a measure of total income and characterization of "social markets" (my term) are especially provocative, and they should merit extensive professional dialog.

Eldon E. Weeks

Waterfowl and Wetlands: Toward Bioeconomic Analysis

By Judd Hammach and Gardner Mallard Brown, Jr. Published for Resources for the Future, Inc., by the Johns Hopkins University Press, Baltimore, Md. 21218. 95 pages. 1974. $7.

A necessary component of resource economic analysis is the evaluation of economic tradeoffs of alternative uses of resources. Hence, the value of an additional unit of the resource, whether it be land, water, labor, or waterfowl, needs to be determined. This book looks at the difficult problem of valuing existing prairie wetlands for waterfowl and explores the questions of how many waterfowl and ponds are appropriate in a dynamic setting. The book makes three important contributions to the field of resource economics: (1) a theoretical and empirical framework for linking economic and biometric information; (2) empirical estimates of the marginal value of wetlands together with estimates of optimal number of ponds, breeders, and seasonal kill; and (3) a limited discussion of policy implications of optimal management programs.

The book contains only 95 pages and six chapters, and one wonders if it would normally be considered a technical bulletin or monograph. The text is well written and organized. It presents a brief review of the problem, and a review of the literature dealing with alternative methods of valuing outdoor recreation; develops a theoretical framework and empirical results for the valuation of waterfowl; develops a theoretical model and empirical results for the biometric relationship of mallards; uses the developed information to provide a cost-benefit anaylsis; and discusses some policy implications, limitations, and recommendations for future studies.

The authors should be commended on their approach to an important economic and biologic resource problem. Their work ties resource demand and supply together with optimal management programs. This type of analysis has been lacking because of the amount of information available on the supply side, in particular the biological relationships, and the problem of estimating demand functions for natural resources. Future research and planning involved with water and related land resource should not treat fish and wildlife values as a nonquantifiable externality or indirect effect, but treat these resources as primary outputs. Considering the Water Resource Council's "Principles and Standards," such a measure of tradeoffs will be mandatory for developing plans under two objectives and four accounts.

The book is based on a survey of 4,900 hunters during the 1967-68 season. The questionnaire and comments of respondents are presented in the appendix. The questionnaire attempts to elicit an estimate of both willingness-to-sell (through a hypothetical sale of hunting rights for a season) and willingness-to-pay variations of consumers' surplus. The data are analyzed using regression anaylsis on various equations and forms of equations. The book then switches from economics to biometrics and develops the theoretical model for waterfowl production and survival functions. After determining maximum physical sustained yield and the steady-state mallard kill at various levels of breeding population, the optimum harvest is determined.

One of the more interesting results is the insensitivity of the kill to the number of breeders, holding the pond count constant. Although this insensitivity has long been known, the authors give the following quantitative results: ". . . increasing breeders 100 percent from 5 million yields a harvest increase of only about 11 percent. On the other hand, increasing the number of ponds while holding the number of breeding adults constant, shows that 114 percent increase in ponds yields a 69 percent increase in harvest."

Chapter 5 discusses optimal management programs by combining the biometric information with the marginal valuation of waterfowl. Assuming that the marginal value of the bagged waterfowl is $3.29, 2.7 birds per acre are produced, hunters shoot 2.05 of the birds and still maintain breeder population (using the steady-state equation), and 80 percent of the birds are bagged, then the value of wetlands is $5.40 (1.64 x $3.29). This value compares favorably to Canadian wetland easements averaging $4.72 per acre. Discounting at 6 percent, an asset yielding $5.40 has a present value of $90 which compares favorably with wetlands valued at $25 to $50 per acre in the Dakotas and western Minnesota.

Although these values are not exact, the reader feels that given the theory and empirical work they are a fairly good estimate. More important, the work represents one of the first attempts to join economic and biological relationships to determine the optimal number of ponds, breeders, and seasonal kill, together with a benefit-cost anaylsis of wetlands. This work definitely has made a contribution to resource and bioeconomic analysis and would be an excellent reading assignment for a graduate course in resource economics.

Robert B. McKusick

The Agricultural Systems of the World: An Evolutionary Approach

By D. B. Briggs. Cambridge University Press, New York 10022. 358 pages. 1974. $7.95

Traditionally, agricultural innovations have been slow to come about; indeed, on appearances, the agricultural sector of our economy might seem transfixed in inertia. Accordingly, when some degree of change occurs it is dramatic by contrast to other sectors, and usually what by historical analysis would be classified as an evolution is by impression a revolution.

To understand the current situation in agriculture is essential to know how modern agriculture evolved. The objective of this book is to describe the major characteristics of agricultural regions of the world and to explain how they were formed. To a large extent the objective has been achieved but at a trying expense to the reader, who must wade through dull statistics and narrative.

The most significant factor determining the current distribution of the major types of agriculture was the slowness of the technical changes in agriculture until the 19th century and the limited areas in which the new techniques of the 19th and 20th centuries have been adopted.

Until the 17th century there was little difference in agricultural activity among the farm communities of Europe, India, and China. Then some slight changes appeared, but the major breakthrough came in the 19th century with the introduction of laborsaving machinery. This was largely attributable to increased migration to towns late in the century which caused a decline in agricultural population, thus compelling farmers to adopt mechanical devices. Essentially what the author contends is that the increase of population has caused

the intensification of agriculture and thus led to changes in the type of farming in a particular area. However, though these changes initially came in the later part of the 19th century, they were not widely adopted until the 1930's. This was a period of agricultural revolution in Western farming. Simultaneously, higher incomes led to a shift in demand from grain to livestock products, vegetables, and specialized tropical products, while factories generated a demand for cotton, wool, jute, rubber, and vegetable oils.

While Western farming was being revolutionized, the agricultural tradition in Asia, Africa, and a large part of Latin America was basically unaltered. The peasant farming system of those areas has varied little from the past, compared with the Western agricultural world. Regardless of area, the past is firmly imprinted in the minds and ways of the farm communities all over the world—although perhaps a little less now than formerly.

Jack Ben-Rubin

The Hoover-Wilson Wartime Correspondence, September 24, 1914, to November 11, 1918

Edited by Francis W. O'Brien. Iowa State University Press, South State Avenue, Ames, Iowa 50010. 297 pages. 1974. $7.95.

Many of the problems discussed in this book have parallels today: political implications in relief exports of food; practicability of an international food bank; allocation to domestic consumption vs. overseas markets; farmers holding commodities for higher prices; dissatisfaction with price levels that lag behind costs; and control of excess profits, to mention some of those most related to agriculture.

The outbreak of World War I has presaged economic and social problems unmatched in history. Herbert C. Hoover, who was later to become head of the United States Food Administration, Secretary of Commerce, President of the United States, and an authority on administrative management, received wide recognition for his relief work in wartorn areas.

While theses and books have been published about Hoover and by him, only William Starr Myers has previously published papers relating to Hoover's presidential administration (*The State Papers and Other Public Writings of Herbert Hoover*, 2 vols., New York, Doubleday, Doran and Co., 1934).

Francis O'Brien, Director of Academic Programs for the Hoover Presidential Library Association at West Bend, Iowa, has done admirable work in compiling the first of several volumes of correspondence between Herbert Hoover and President Wilson. Entries are in strict chronological order, thus separating the initial letter from the reply.

Unfortunately, those using the book will find the index not as inclusive as they may wish. Its three pages have no commodity entries. Many names are not covered. Even the Food Administration is only sketchily covered, with nothing on its organization. An entry is given for the Price Fixing Board, but entries on prices are scattered under names of key figures such as Hoover, Secretary of Agriculture Houston, or Senator T. P. Gore.

Nevertheless, O.Brien's compilation offers insights that give greater understanding of today's economic problems in American agriculture.

Vivian Wiser

U.S. GOVERNMENT PRINTING OFFICE :1975 O - 590-130

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The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director, Office of Management and Budget, through February 28, 1980.

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